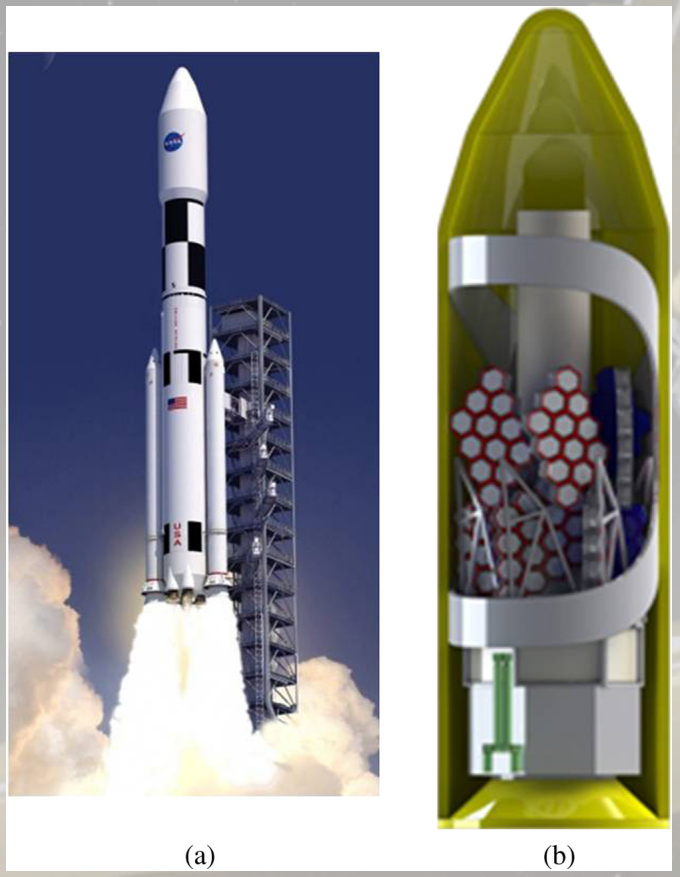
Goddard SPACE FLIGHT CENTER

JPL

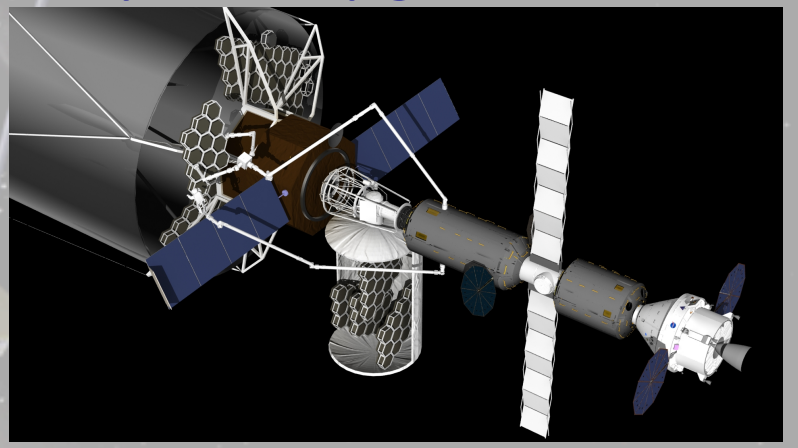
marshall

SPACE TELESCOPE SCIENCE INSTITUTE
Operated for NASA by AURA

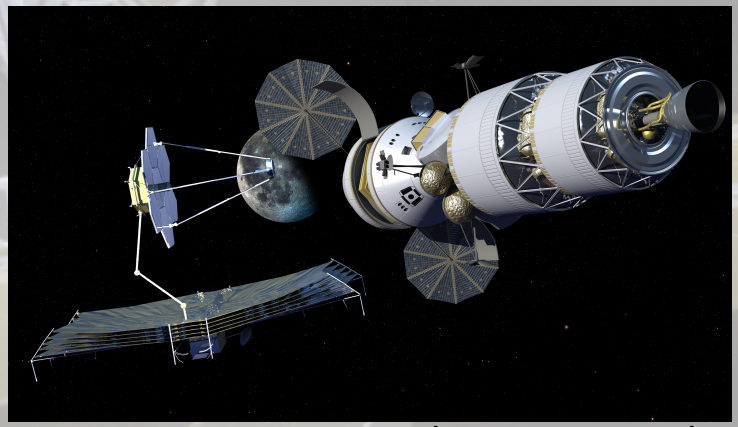
The Advanced Technology Large-Aperture Space Telescope (ATLAST) and On-Orbit Assembly and Upgrade



Modular Assembled Space Telescope (MAST) via SLS (2013)



~20 m design (2014)



~8 m design (2008)

Astronauts and robots with a long-duration hab: assemble and service the observatory to search for biomarkers in Earth-like worlds.

Affording Mars

Selected Recommendations from A Community Workshop

Harley Thronson
NASA GSFC
and
Chris Carberry
Explore Mars, Inc.

The Global Exploration Roadmap Workshop
April 10 – 11, 2014

The First "Affording Mars" Workshop

December 3 – 5, 2013
George Washington University

- Co-sponsored by Explore Mars, Inc. and the American Astronautical Society
- Attempted to be representative: about 60 participants from 20 institutions
- Organized around plenary discussions and three breakout sessions
- Follow-on activities continuing, including a second workshop
- Formal reports available at http://www.exploremars.org/

Summary Recommendations

- Initial human missions to Mars are affordable, but only if a handful of principles are strictly followed.
- Human space flight activities not directly related to human exploration of Mars may be costly distractions.
- Decisions on architecture and technology priorities must be made in the very near future.
- The Mars architecture must be design-to-cost.
- Broad and deep community involvement is essential.
  - *Science participation was extremely valuable*
- "LEO directly to Mars" is not feasible: an interim habitation facility to gain experience should be a priority.

Why Mars?

"By the mid-2030s, I believe we can send humans to orbit Mars and return them safely to Earth. And a landing on Mars will follow."

--- President Barack Obama, April 15, 2010

- Ultimate goal for NASA and its international partners
- Consensus ultimate destination among stakeholders
- Growing number of designs support its technological feasibility and far more affordable than widely believed . . .and cited
- Strong public support as the most compelling destination for human space flight

Why "Affording Mars" Workshop?

- Many commentators casually cite very large numbers – "trillion dollar Mars mission"
- International space policy has shied away from Mars in part because of the perception of very high cost
- Multiple independent design studies – albeit preliminary – support the affordability of initial human missions to Mars

The workshop organizers felt the need to confront the "budget buster" myth head-on . . .and need to do this as a community.

Workshop Follow-On Activities

Our workshop was followed by a planned series of briefings, media coverage, presentations, and publications, including

- Briefings to NASA Headquarters senior staff
- Meetings on Capitol Hill
- Discussion with OSTP
- Professional presentations and publications
- Second workshop under construction

See workshop summary presentation at http://spirit.as.utexas.edu/~fiso/telecon/Raftery-Cassady_2-19-14/

Workshop Charter

Design concepts, alternatives, and technologies were open for discussion. However, the workshop focused on how to achieve affordability, priority HSF activities in the coming decades, and high-level process to achieve affordability.

The workshop assumed some groundrules to make progress:

- SLS and Orion will be available during the time periods considered by the workshop.
- The International Space Station will play a critical role in preparing to travel beyond LEO.
- Robotic missions will enable human missions to Mars.
- There are emerging scenarios and capabilities that will influence mission architecture and planning over the next two decades.

Breakout Session Topics

- The ISS as a Platform to Advance Exploration
- Affordability and Sustainability of Human Mars Exploration
- Notional Sequence of Missions Leading to Humans on Mars

Nota bene: my emphasis in following charts in red.

Major Principles of Agreement (1)

- Mars should be the overarching goal of human space flight over the next two to three decades, consistent with U.S. space policy.

- Identifying and solving key technical gaps over the next several years will be important in making the human exploration of Mars feasible by the 2030s. Between now and then, human exploration of deep space must be prioritized in a manner that advances the objective of human exploration of Mars starting in the 2030s. Other goals for human space flight will be costly diversions.

"If you intend to take Vienna, then take Vienna!"-- Napoleon

Major Principles of Agreement (2)

- Taking advantage of ISS, especially including international partnerships, is essential for human missions beyond LEO and, especially, to Mars.

- Continuation of robotic precursor missions to Mars throughout the 2020s is essential. The robotic Mars exploration science strategies of NASA and ESA should be coordinated with humans-to-Mars efforts while preserving their primary science objectives.
  - Scientists made valuable contributions throughout the workshop planning and output.

The two astronomers engaged to rebuild London after the Great Fire of 1666.

Major Principles of Agreement (3)

- International and industrial partnerships, efficiency, consistency of purpose, and policy/budget stability are the required elements to allow a two decade-long humans-to-Mars (H2M) effort to succeed.

Selected Recommendations: Breakout Session 1

This breakout session included extended discussion of an interim step in the 2020s between human spaceflight in LEO and the human exploration of Mars. One option discussed is a modest, short-lived human-tended facility in the vicinity of the Moon.

Recommendation 4: The ISS program should:

- define objectives and conceptual designs for this "bridge" facility, including the options for using hardware supplied by international partners
- evaluate the objectives that must be satisfied, and determine the most efficient and effective way of achieving them: ISS, habitation facility on orbit in the lunar vicinity, or other.

Breakout Session 2:
Affordability and Sustainability of Human Missions to Mars

Considerable discussion at the workshop was devoted to the definition of "affordable" in the context of a human mission to Mars. In a breakout session devoted to this topic the following definition was adopted for the purposes of the workshop:

A strategy that enables success within a budget and timeframe justified by the importance of mission goals. [That is, design to cost.]

In addition, "sustainable" in the context of the workshop was used politically and financially, in contrast to engineering sustainability. That is, there was general agreement that engineering solutions can be found to sustain human Mars missions, while the greatest challenge facing a successful program is political commitment and sustainability.

Breakout Session 2

Principles for Human Exploration of Mars (1)

Establishing a well-thought-out, widely vetted, and compelling plan for the initial human missions to Mars with a regular cadence of achievements is the highest priority for the national space agencies. Sustainability and affordability of this plan can be achieved. To do so it is also important that the space community and policymakers agree on and construct a strategy that incorporates the following suggested principles:

- All human space exploration and related robotic activities must be prioritized and conducted with the requirement that a human landing on Mars is the overarching goal for human space flight. Deviation from this will lead to delays from which it will be difficult to recover.
- Continuity and stability of programs and budgets: Budgetary and policy consistency are essential. As such, the space communities need to design programs/missions that lend themselves to budgetary stability and take an incremental approach to constructing a program.

Breakout Session 2

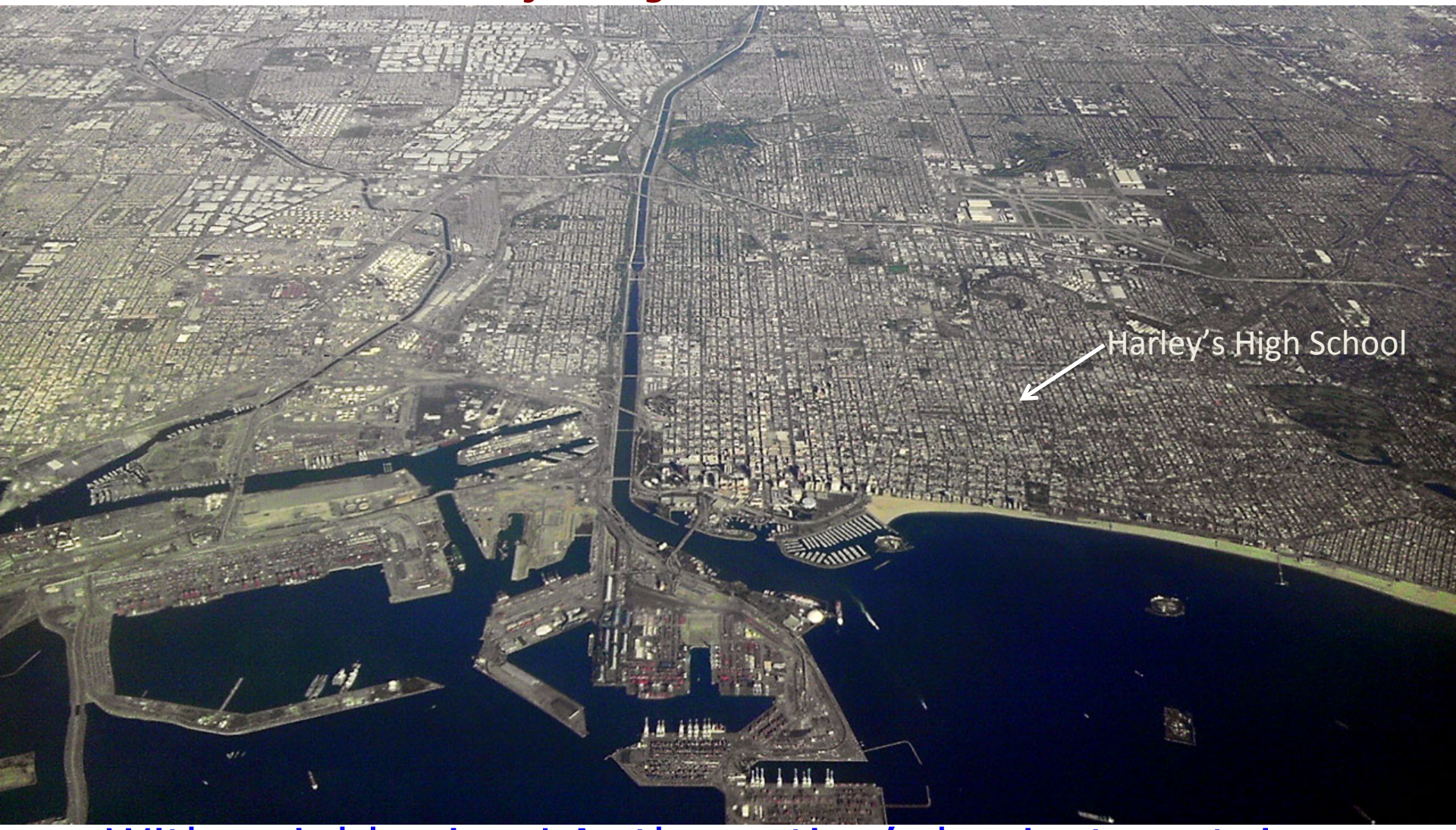
Principles for Human Exploration of Mars (3)

- Establish ambitious dates for compelling near-term milestones to enable efficient use of resources and expedited management, while protecting sufficient flexibility to adjust for developments of capabilities, new discoveries, and changing political environments. Example milestones over the coming decade could include

  - Successful demonstration of SLS and Orion
  - A Mars "free-return" mission using SLS and Orion
  - Sustained robotic science-driven exploration coordinated with human space flight goals
  - Regular progress on relevant technology capabilities developed on ISS
  - Deployment of a transitional deep-space facility in the early 2020s*

*_Cf._ Arthur C. Clarke (1961), Farquhar (1971), NASA-CU (1987), JSC (1990s), DPT (2000), Three-Team Review (2005) . . .

A Lesson of Long Beach Harbor:
A Naturally Occurring Destination is Not Necessary to Carry on Major Logistics Activities



With neighboring LA, the nation's busiest container port area was <u>not</u> built from a natural harbor.

Breakout Session 3:
Notional Sequence of Missions Leading to Humans on Mars

Breakout session 3 of the workshop concentrated on potential mission sequences for achieving a human mission to Mars. The purpose of the third breakout session was to begin the process of assessing these options.

It is clear that a top-level set of requirements are needed. [These are often called Level 0 requirements.] Although it was beyond the scope of a three-day workshop to define these top-level requirements, the following list was used to guide the discussions:

- Human Mission to Mars by the 2030s
- Incremental Approach: Near-Term and Regular Accomplishments
- Realistic Budgets
- International Program
- Public and Stakeholder Engagement
- Sustainable Approach
- Clear Science Objectives

Recommendation: Detailed assessment of mission options is a priority effort that will require dedicated resources. This activity is proposed to take advantage of the Global Exploration Roadmap (GER) and associated activities, although with more detailed engineering analysis

Summary Recommendations

- Initial human missions to Mars are affordable, but only if a handful of principles are strictly followed.
- Human space flight activities not directly related to human exploration of Mars may be costly distractions.
- Decisions on architecture and technology priorities must be made in the very near future.
- The Mars architecture must be design-to-cost.
- Broad and deep community involvement is essential.
  - *Science participation was extremely valuable*
- "LEO directly to Mars" is not feasible: an interim habitation facility to gain experience should be a priority.